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ORIGINAL ARTICLE

Study on Entomological Surveillance and its Significance during a Dengue Outbreak in the District of Tirunelveli in Tamil Nadu, India

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Abstract

Objectives: To study the significance of entomological surveillance, the house index (HI), container index (CI), and Breteau index (BI) were determined to estimate the degree of a major dengue outbreak in Tirunelveli, Tamil Nadu, India (Latitude: 8°42′N; Longitude: 77°42′E) in May 2012.

Methods: The HI, CI, and BI were determined in a primary health center (PHC) in the village of Maruthamputhur (Pappakudi taluk, Tirunelveli) by carrying out an antilarval (AL) work that involved door-to-door search for immature stages of *Aedes* spp. mosquitoes by trained field workers and volunteers. The work of field workers was evaluated by a junior and senior entomologist the following day.

Results: Before the AL work, the reported numbers of fever cases from Week 1 to 5 in Maruthamputhur were 211, 394, 244, 222, and 144 with two deaths. By contrast, after the AL work, these numbers were considerably reduced and there was no fever-related death (the HI was reduced from 48.2% to 1.6%, the CI from 28.6% to 0.4%, and the BI from 48.2 to 1.6).

Conclusion: Because no specific medicine and vaccines are available to treat dengue fever and dengue hemorrhagic fever, entomological surveillance and its significance can be used to halt the outbreak of dengue as shown in this study.

1. Introduction

Dengue is an acute febrile illness caused by *Flavivirus*, which exists in four different serotypes, namely, DEN-1, DEN-2, DEN-3, and DEN-4. Its transmission is effected through female *Aedes aegypti* and *Aedes albopictus* mosquitoes (vectors). Dengue fever (DF) may transform into dengue hemorrhagic fever (DHF) and

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dengue shock syndrome (DSS) and these conditions are fatal causing hemorrhages and leakage of plasma, respectively [1]. This mosquito-borne disease not only causes high levels of morbidity and mortality, but also has a great economic impact, including loss in commercial and labor output, particularly, in tropical and subtropical countries. However, no part of the world is free from these diseases [2]. To prevent and control the spread of dengue, various approaches have been attempted and most of them yielded fruitful results, with vector control proving to be the best approach until dengue-specific drugs and vaccines are developed [3]. There are three major components of dengue surveillance, namely, disease surveillance, vector surveillance, and monitoring of environmental and social risks. Among these components, entomological surveillance is used to determine changes in the geographical distribution and density of the vector, evaluate control programs, obtain relative measurements of the vector population over time, and facilitate appropriate and timely decisions regarding interventions [4]. A number of methods are available for detecting or monitoring immature and adult populations. Selection of appropriate sampling methods depends on the surveillance objectives, levels of infestation, available funding, and skills of personnel [5]. The objectives of *A. aegypti* surveillance methods are baseline infestation survey, control program monitoring low infestation levels [$<5\%$ house index (HI)], control program monitoring with $\geq 5\%$ HI level, surveillance against reinfestation, verification of eradication, and evaluation of control methods. These objectives have been accomplished with larval survey, collecting data on mosquito landing on humans or biting them, collection of resting mosquitoes, ovitrap, tire larvitraps, and insecticide susceptibility based on their suitability [6].

Several indices have been used to monitor *A. aegypti* populations for dengue virus transmission. Those related to immature populations are the HI, i.e., the percentage of house infested with larvae or pupae; the container index (CI), i.e., the percentage of water-holding containers infested with larvae or pupae; and Breteau index (BI), i.e., the number of positive containers per 100 houses inspected. When using the HI or the BI, the definition of a house should be one unit of accommodation and the surrounding premises, irrespective of the number of people residing therein [7,8].

In this study, efforts have been made to understand the significance of entomological surveillance using the HI, CI, and BI during a dengue outbreak (May 2012) in Tirunelveli district of Tamil Nadu, India, and to incorporate the study findings in the dengue-control measure protocols.

2. Materials and Methods

2.1. Active fever surveillance

Information on fever was collected with the resources available by active (door-to-door search) and passive surveillance (institutional surveillance), as fever is the prime sign and symptom for DF. A door-to-door search (active surveillance) was performed by field staffs, health inspectors, and village health nurses during their field visits. Based on the data collected, malaria form 2 was filled in and a blood smear test was conducted to rule out malarial fever. The form along with the test results were sent to the medical officer at the primary health center (PHC). In addition, the S form of the Integrated Disease Surveillance Project (IDSP) was also filled out in order to understand the clinical syndromes of diseases such as malaria, dengue, leptospirosis, and acute diarrheal diseases in the community, with the case definition defined in the IDSP Manual [9]. A copy of the S form was also sent to the medical officer at the PHC. It would also be helpful to identify (using event-based surveillance) whether disease clusters are present in a place. Based on the reports submitted and laboratory test results, decisions can be made for implementing specific disease-control measures.

2.2. Case definition of dengue

According to the IDSP manual, dengue is defined as an acute febrile illness of 2–7-day duration with two or more of the following symptoms: head ache, retro-orbital pain, myalgia, arthralgia, rash, hemorrhagic manifestations, and leucopenia.

2.3. Passive surveillance

Passive surveillance is an institutional surveillance using which information about the spectrum of diseases can be obtained. For the present study, passive surveillance was used to collect daily information on fever from the outpatients of the PHCs and inpatients of government hospitals, private nursing homes, and sentinel surveillance hospitals (tertiary care hospitals such as medical college hospitals) in the district. Based on this information, the entomological surveillance was prioritized.

2.4. Entomological surveillance

Entomological surveillance was used for the antilarval (AL) and antiadult measures. The AL work was performed by skilled field workers and trained volunteers by identifying immature stages of *Aedes* spp. in common mosquito habitats near the premises of human dwellings such as tires, coconut shells, cement cisterns, overhead tanks. These sources were removed with all possible efforts and in cases where removal was not possible larvicide [50% temephos (Abate) emulsified concentration at the dosage of 1 ppm] was used to kill the mosquito larvae.

To manage manpower, the AL work was performed in a village by dividing it into six-day blocks from Monday to Saturday. All dwellings of each block were thoroughly checked by workers on the specified day. One worker was allotted for every 60 houses, so that sufficient numbers of workers are available to cover all the houses in a village. The 6-day block was recommended based on the life cycle of mosquitoes as it usually takes between 7 and 10 days for the imagoes to emerge from the eggs.

Antiadult measures were carried out using ultralow-volume thermal fogging with a formulation of pyrethrum (a synthetic pyrethroid compound) and diesel in the ratio of 1:19. The fog was created by PulsFOG machines and vehicle-mounted fogging machines. Because dengue vectors *A. aegypti* and *A. albopictus* have diurnal periodicity, fogging was performed from 8 AM to 11 AM and from 3 PM to 5 PM following the condition of wind velocity and speed of vehicle (6–10 km/h). People were instructed to properly cover the food, keep the infants away from mosquito dwellings, keep the doors and windows open during fogging and close them after fogging for half an hour so as to ensure the knockdown effect of the insecticide [10].

2.5. Entomological indices

Entomological indices, namely, HI, CI, and BI were computed from the daily data collected in the AL work for assessing its impact. To calculate these indices, the following formulae were used:

$$\text{House index(HI)} = \frac{\text{Number of houses positive with } \textit{Aedes} \text{ larvae or pupa}}{\text{Total number of houses searched}} \times 100$$

$$\text{Container index(CI)} = \frac{\text{Number of wet containers found positive with } \textit{Aedes} \text{ larvae}}{\text{Total number of wet containers searched}} \times 100$$

$$\text{Breteau index} = \text{Number of wet containers found positive in 100 houses}$$

Antiadult measures were assessed by bioassays and per man-hour density (PMHD) of mosquitoes through hand collection. The PMHD is number of mosquitoes collected by a man in an hour using a mechanical aspirator.

2.6. Appraising method for the AL work

To appraise the AL work performed by the field staff and trained volunteers, a junior and senior entomologist investigated a minimum of 25 houses in which the field workers carried out the AL work the previous day. The data collected by the entomologists and field workers were matched and any inconsistency was discussed in the daily review meeting in order to improve the quality of work by the field workers. This method was continued every day until the outbreak was halted completely.

2.7. Community participation

To encourage the communities to take part in vector-control measures, various information education and communication activities were conducted during the course of dengue outbreak, which included demonstration of *Aedes* larvae to the people in their house premises, information about the variety of habitats, periodicity of the mosquito as it is diurnal, importance of source reduction, and scrubbing of water-stored vessels as its eggs can withstand humidity for even a year and can resume life when the container becomes wet with water, the importance of weekly interventions of these activities as the life cycle of mosquitoes is only 7–10 days, etc. These activities were conducted in school meetings in which the students took oath during their daily prayers to control dengue by reducing the various sources of *Aedes*, antidengue awareness program through public addressing system, local telecast, and interpersonal communication.

2.8. Statistical analysis

The values of the indices calculated by both field workers and appraisers were analyzed by Chi-square test using the Statistical Package of Social Sciences version 12.0 (SPSS Inc., Chicago, IL, USA). A p value < 0.05 was taken to be significant.

3. Results

This study was carried out in Maruthamputhur village (Tirunelveli, Tamil Nadu, India; Latitude 8°42′N, longitude 77°42′E) wherein there was a dengue outbreak in May 2012. The primary information on fever was obtained from various resources (Figure 1) to understand the degree of outbreak and to prioritize the AL and antiadult measures to be undertaken.

To determine the impact of the entomological surveillance, the data collected on fever in a week were taken as before and after entomological intervention. Before the AL work, the reported numbers of fever cases from Week 1 to 5 in Maruthamputhur were 211, 394, 244, 222, and 144 with two deaths, which shows the magnitude of the problem. Among outpatients at PHCs in Maruthamputhur, all probable cases of dengue were identified according to the case definition in the IDSP manual. In accordance with this, nine, 36, 15, 10, and nine cases of fever (with an onset period less than 7 days) in Weeks 1—5, respectively, were referred to the sentinel hospital for laboratory confirmation. The test results were found to be positive for dengue virus infection based on the detection of NS1 antigen and immunoglobulin M (IgM) antibodies in IgM capture enzyme-linked immunosorbent assay (Figure 2).

An observation on entomological surveillance data revealed that the HI, CI, and BI were above the permissible level in the 1st week of intervention, but their values gradually reduced after the AL and antiadult measures. The HI, CI, and BI was 48.2%, 28.6%, and 48.2% before the entomological intervention; however, after the intervention these indices were considerably reduced as the HI values were 10.2%, 5.2%, 2.5%, and 1.6% in the 2nd, 3rd, 4th, and 5th week, respectively; the CI values were 2.3%, 0.9%, 0.4%, and 0.3%, respectively; and BI values were 12.9%, 6.2%, 2.8%, and 1.6%, respectively. The weekly progress of *Aedes* indices during the entomological surveillance is shown in Figure 3. These findings reflected the considerable reduction in the population of *Aedes* spp. (both pupae and adult) and subsequently a reduction in the number of

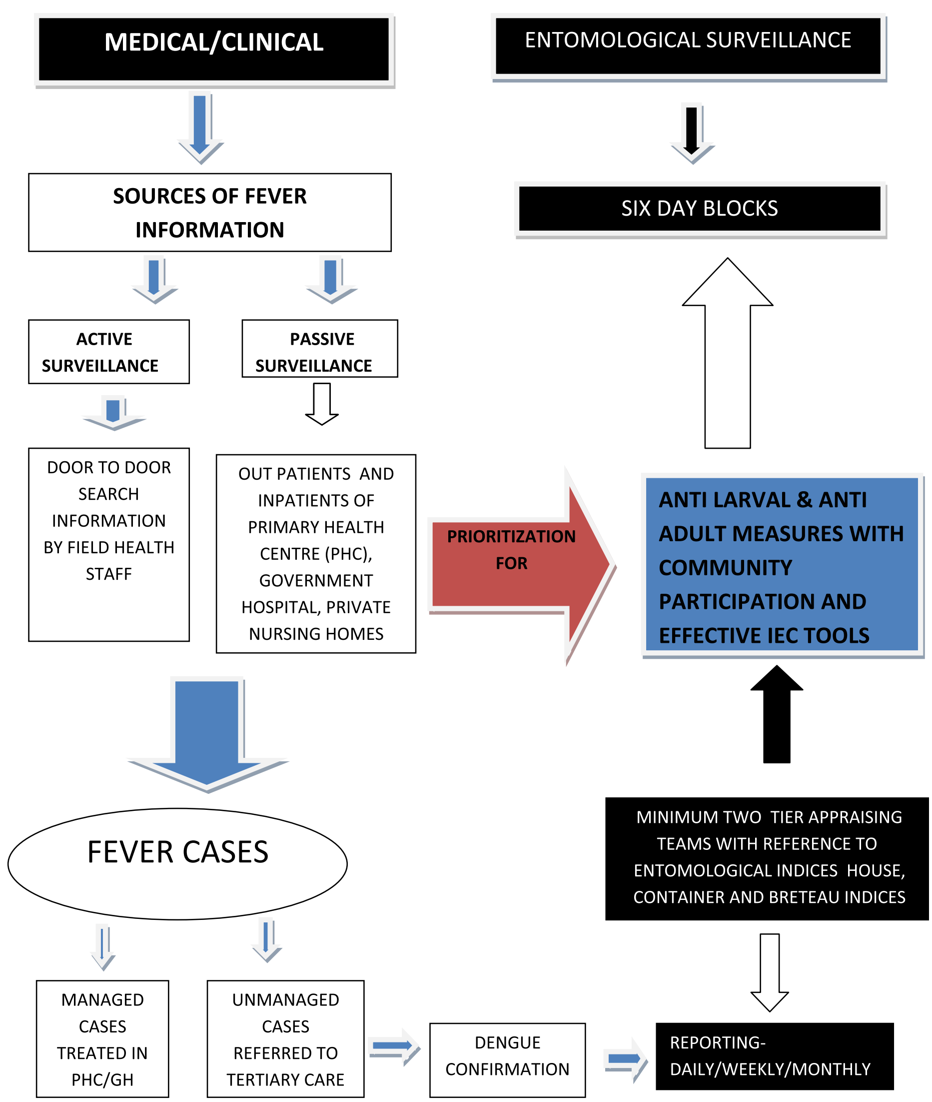

Figure 1. Comprehensive flow chart for dengue outbreak response.

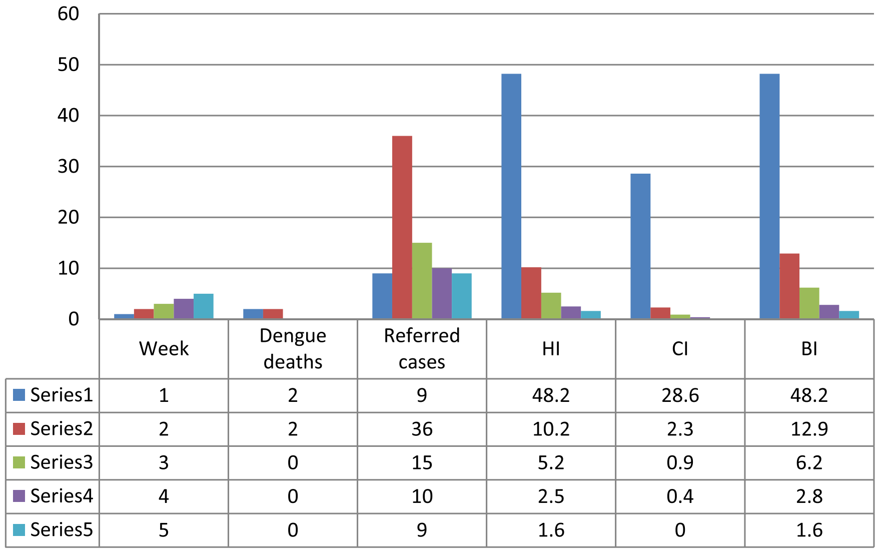

Figure 2. Impact of entomological intervention during the dengue epidemic in Maruthamputhur PHC of Tirunelveli district of Tamil Nadu, India.

dengue cases reported. No deaths due to dengue were reported after the intervention (Figure 4).

The AL work performed by field workers was appraised by a junior and senior entomologist who inspected a minimum of 25 houses. We also found that there was a consistent reduction in the value of the indices from the 1st week of intervention onward. When the data of appraisers were matched with those collected by field workers, some inconsistencies were found ($p > 0.005$). Because these data reflect the quality of AL work, inconsistencies were reviewed in the daily meetings in order to improve the quality of AL work. Among the referred cases, no death was reported from the 3rd week. The incubation period of the dengue virus is 4−14 days [11], which was also considered to appraise the quality of AL work, i.e., if the interventions were successful, there should be a descending trend from the second fortnight of intervention. In this study, cases in the first fortnight were 45, but it was reduced to 15, 9, and 0 in the subsequent fortnights, showing the success of the intervention.

During the course of the outbreak, the following have also been observed and highlighted: the HI not only provides information about the geographical distribution, but it also useful as an evaluating tool. We ascertained how long dengue cases might have been prevailing in the community. Children (1−14 years) are more susceptible in the first phase (15 days from the onset of confirmed cases). Deaths indicated the existence of multiple serovars. Shifting of dengue-confirmed cases from children to adults (>14 years) indicated that the mortality rates would be less, as adults have better immunity than children. Any delays in the control of dengue cases within 15 days might reflect on the quality

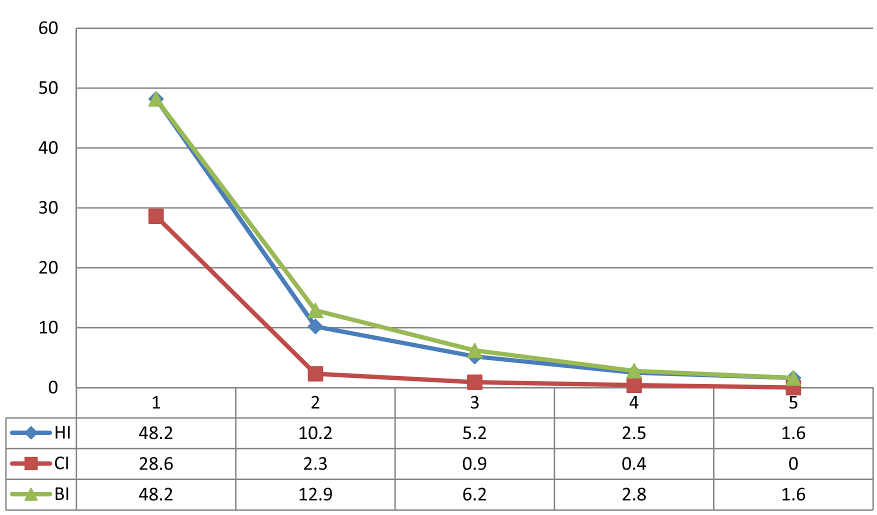

Figure 3. *Aedes* indices during the progress of Entomological Surveillance.

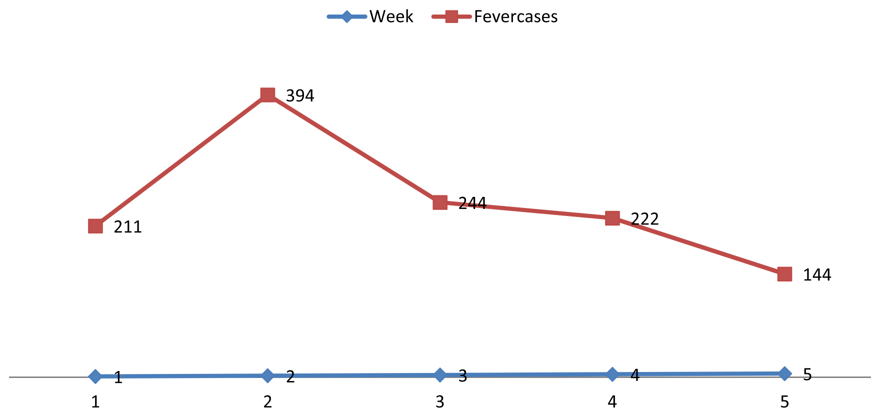

Figure 4. Weekwise fever cases reported in maruthamputhur PHC.

of AL work. While trying to stop the outbreak, the minimum permissible value for both HI and BI was 1.6%, considering the environmental condition of the village (Figure 5).

4. Discussion

Entomological surveillance is an appropriate tool for the prevention and control of dengue outbreak until suitable vaccine and specific drugs for DF, DHF, and DSS are made available. It was ascertained by the World Health Organization (WHO) that preventing or reducing the transmission of dengue virus entirely depends on the control of the mosquito vectors or interrupting the human—vector contact [12,13]. The WHO ascertained that integrated vector management is the best strategic approach to control vectors in all vector-borne diseases, including dengue. The population of dengue vectors was greatly reduced by reducing their sources such as small containers in the premises of human dwellings [14]. It is a proven fact that dengue control is possible only through advocacy, social mobilization and legislation, collaboration within the health sector and other sectors, integrated approach to disease control, evidence-based decision making, and capacity building. Based on these approaches, a nonchemical control was suggested rather than a chemical control, because there is an increased resistance among mosquitoes for chemical controls, while its alternative, various plant alkaloids have also been tried in various dengue vector—control studies [2,15—18]. Above all, promoting the source reduction of *Aedes* species through the AL work along with community participation yielded good results and control of *A. aegypti* was mainly achieved by eliminating water-filled containers that are favorable oviposition sites, which permit the development of the aquatic stages. The habitats are eliminated by preventing access to these containers or by frequently emptying and cleaning them. In unavoidable situations, insecticides, biological control agents, or a combination of both were used, which kills the adult mosquitoes [19].

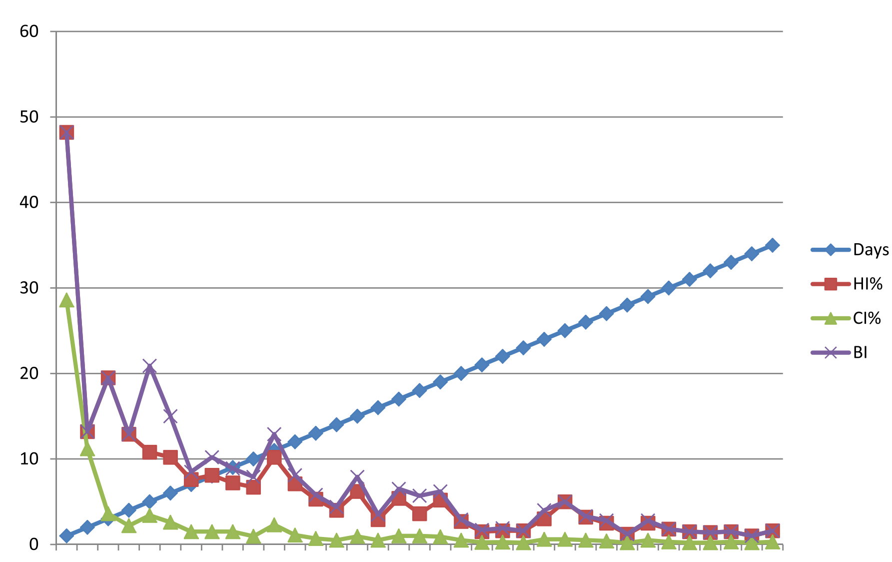

Figure 5. Day wise Aedes larval indices in Maruthamputhur PHC.

Based on the references studied, there were concrete evidences to support the results of the present study in which an outbreak of dengue was effectively controlled through entomological surveillance by carrying out AL work and antiadult measures in the district of Tirunelveli in Tamil Nadu, India, rather than relying on chemical control to which mosquitoes have now become resistance as well as the difficulty in using such controls in clean water sources. By collecting daily reports of fever cases from PHCs, it is possible to know those places or villages that are most vulnerable. These villages could then be prioritized for implementing control measures. The importance of using *Aedes* indices has been proven as an effective tool as there was a rapid reduction in the number of dengue cases and mortality after the AL work. For monitoring the entomological surveillance, an appraising mechanism was used, which is also a novel method or a milestone to evaluate day-to-day control activities of dengue and to assess the quality of AL work. To improve the quality of the AL work, the incubation period of dengue (4—14 days) was considered during the appraising phase. These observations have the merits to be incorporated as a modus operandi in the prevention and control of dengue in any corner of the world.

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